Mobile Distributed 3D Sensing

Sandia National Laboratories

Intelligent Sensors and Robotics

11-09-2001

POC: Chris Lewis 505-844-9224
clewis@sandia.gov

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories

Mobile Sensor Platforms

- **Program Goal: Develop a mobile distributed sensor network for real-time target detection, recognition, and tracking**
- **Two technologies integrated on mobile platforms**
  - **Miniature Intrusion Detection Sensors (MIDS)**
    - **Passive**
    - **Active IR**
    - **Magnetometers**
    - **Seismic**
  - **Video Motion Detection and Tracking**
- **Cooperative distributed intelligence tracks the target's position, heading, and speed.**

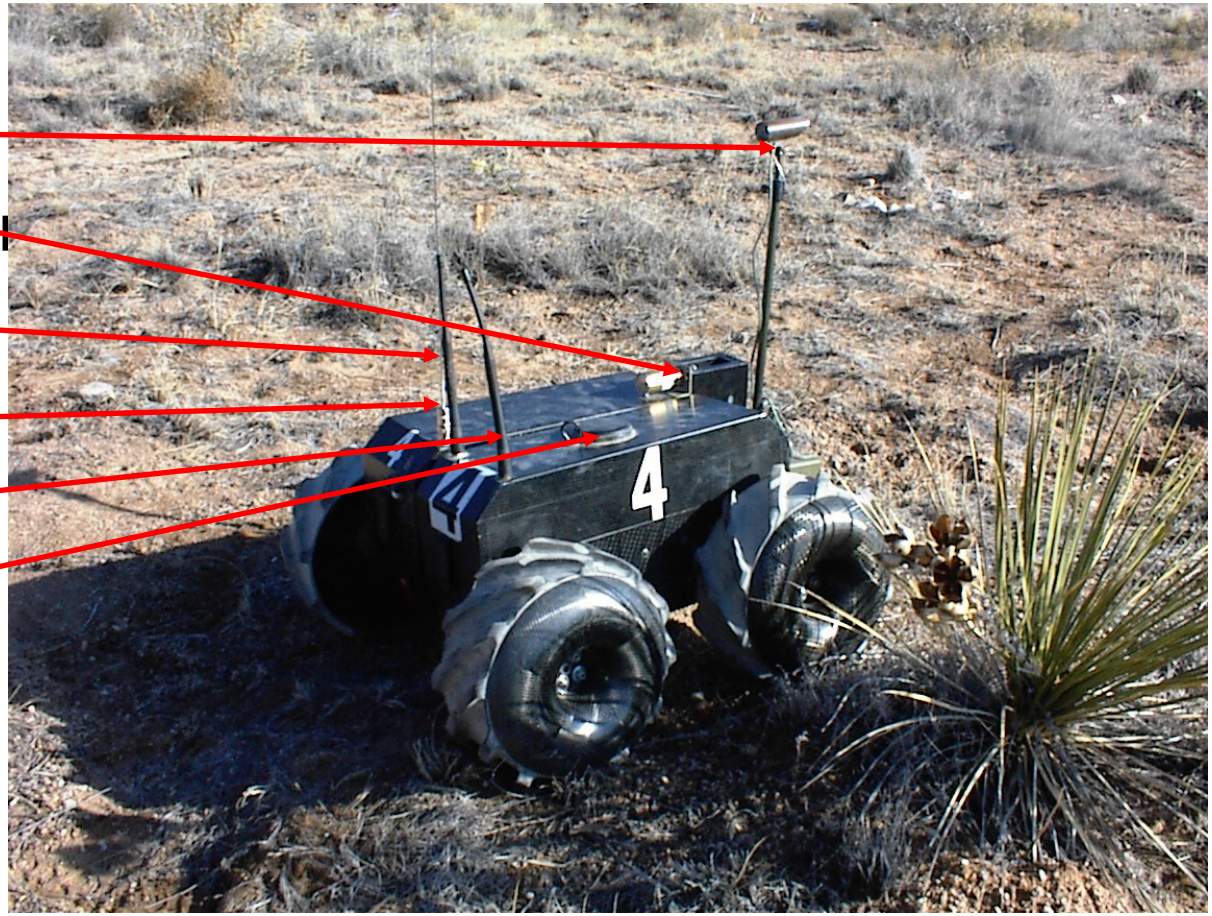
Sandia National Laboratories

Mobile Sensor Platforms

Sandia National Laboratories

MIDS Vehicle

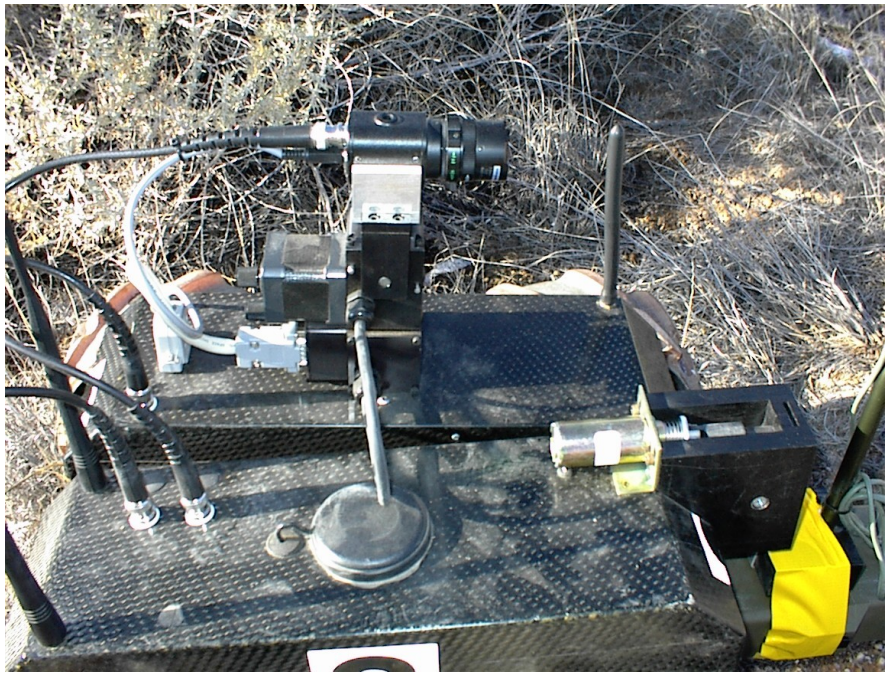
- MIDS Sensor
- MIDS Deployme
- Com. Antenna
- MIDS Antenna
- DGPS Antenna
- GPS Antenna



Sandia National Laboratories

Video Tracking Vehicle

- CCD Camera
  - 90 degree FOV
  - 2.6mm lens
- Pan and Tilt Device
- Video Processed in Right Half of Robot
- Video Transmitter In Left Half of Robot



Sandia National Laboratories

Hound-Bot

- Larger Body
- Tracks
- Low Power Mode
- PIR Sensor on Vehicle

Sandia National Laboratories

Miniature Intrusion Detection Sensors

- **MIDS are strategically placed by mobile robots**
  - **90 day life time using 9-volt alkaline batteries**
  - **GPS location of each MIDS recorded by robot**
  - **Transmits alarm message and ID for each detection**
  - **Manufactured for military applications by Qualtron**

Sandia National Laboratories

PIR Sensor

Sandia National Laboratories

3D Video Motion Detection and Tracking

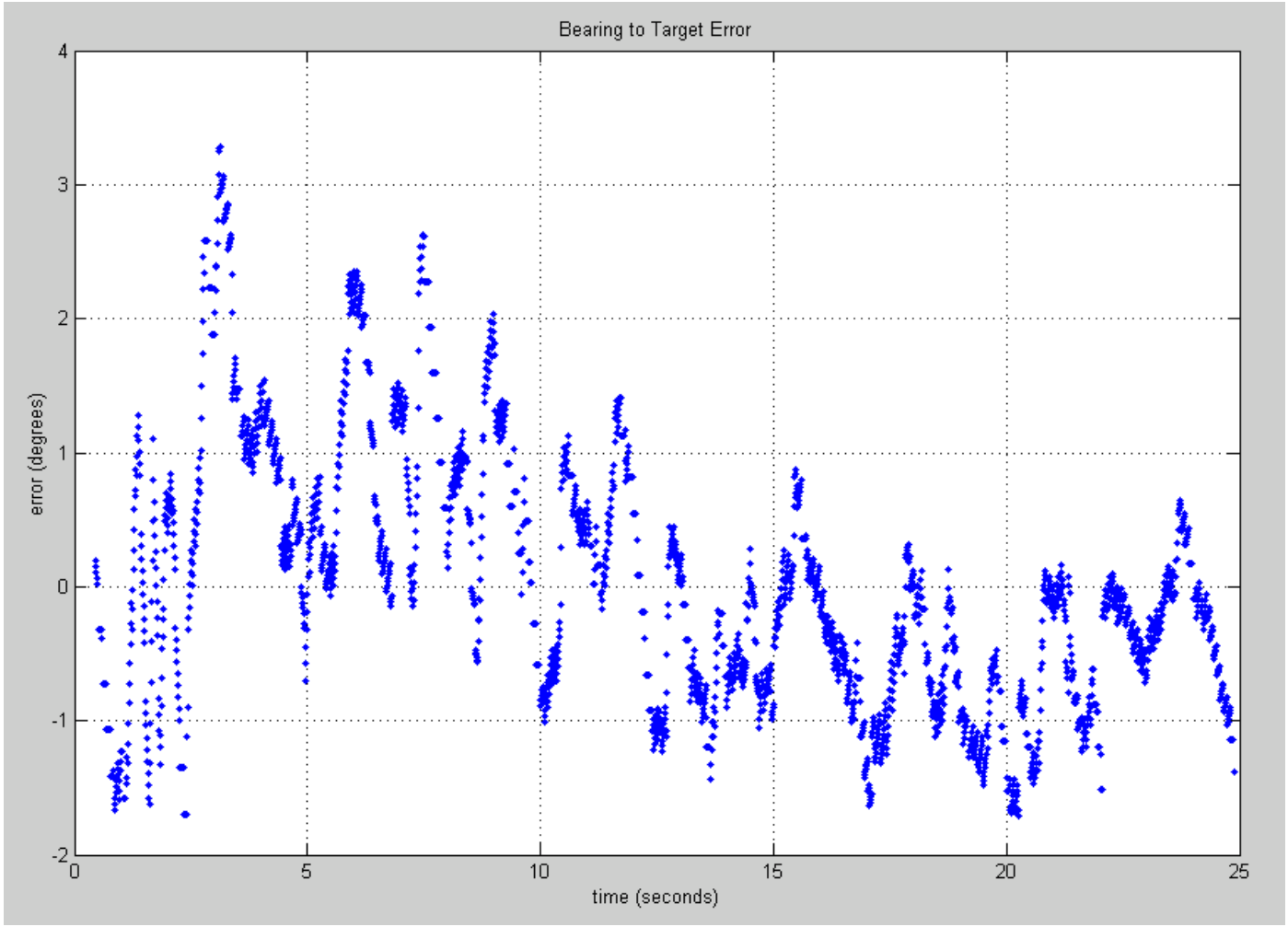
- Each mobile robot is equipped with video cameras and algorithms for video motion detection and tracking
- The motion detection and tracking algorithms are distributed across the robot fleet and can operate independently or collectively
- Wide angle lenses allow targets to be tracked over a 1/4 mile span from a single sensor

Sandia National Laboratories

Video Tracking

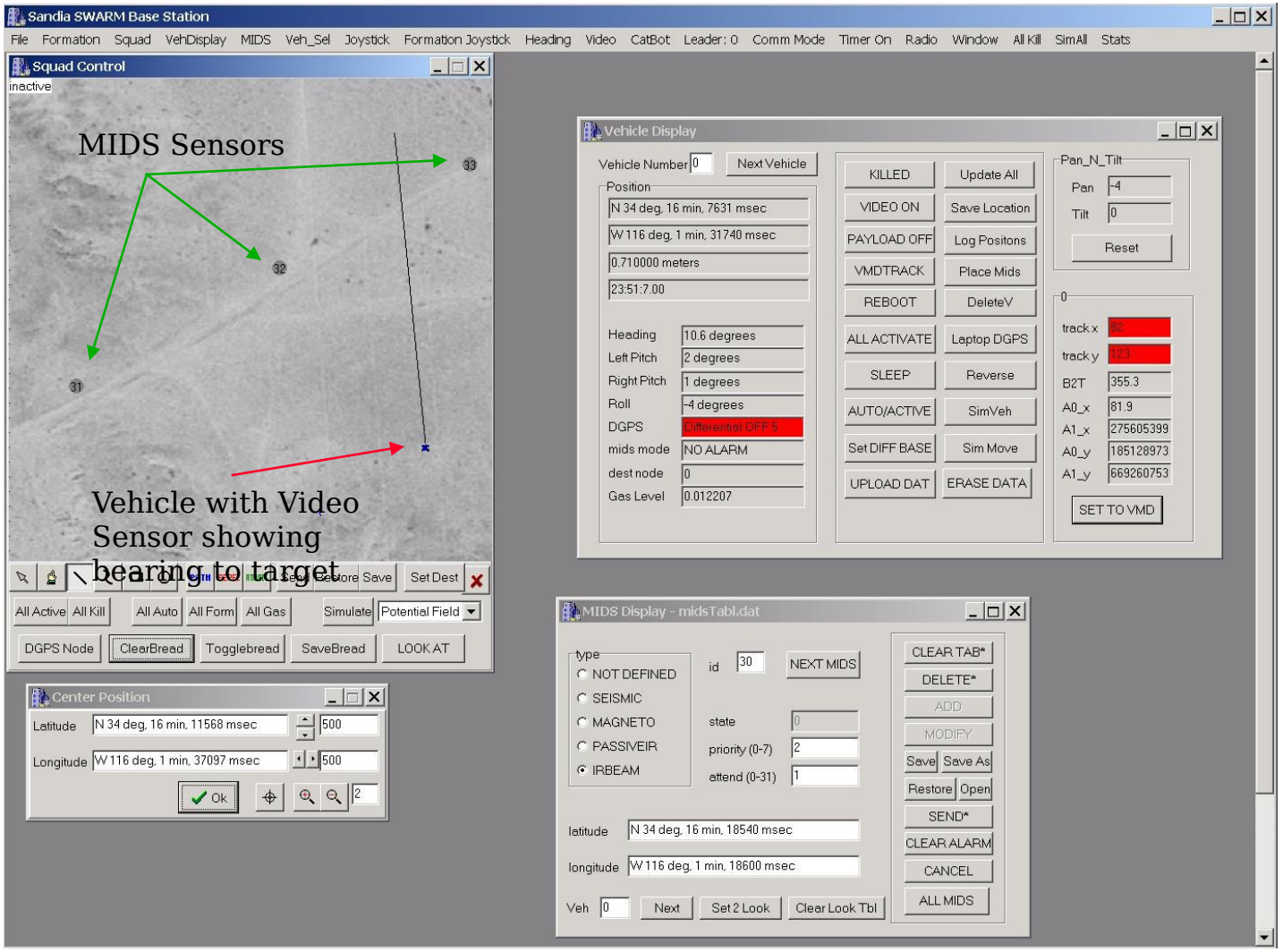
Sandia National Laboratories

Error in Bearing to Target



Sandia National Laboratories

GIS Map, Vehicle & Sensor Status, and Control



Sandia National Laboratories

The Mobile Advantage

- **Re-configurable, self-healing capability**
- **Provides the ability to safely and surreptitiously emplace sensors in denied areas with low risk to personnel**
- **Sensors can be configured and reconfigured for optimal target detection, recognition, and tracking**

Sandia National Laboratories

Progress up to Demonstration

- **Major Tasks**
  - **VMD tracking Integration**
  - **Base Station Modifications**
  - **Vehicle Hardware Modifications**

Sandia National Laboratories

VMD tracking Integration

- Added VMD tracking mode to vehicle control
  - Integrate with vehicle code
  - Memory allocation limits video processing to middle third of image
- Added command and status messages along with associated packet definitions
- Added Pan and Tilt Commands and status messages

Sandia National Laboratories

Base Station Modifications

- Upgraded to Windows 2000
- Added command and status for VMD
- Added command and status for Pan/Tilt
- Added GUI to “Look At”
- Added GUI to display Bearing to Target
- Added GUI to Specify MIDS focus.

Sandia National Laboratories

Vehicle Hardware Modifications

- **Added Pan and Tilt, Cameras, and Video Capture Cards to 4 existing vehicles**
  - **Power: required additional DC/DC Converter**
  - **Cabling: cables span pivot, and surround antennae**
  - **Space: VGA card must be removed for lid to fit**
  - **Mobility: Center of gravity raised, reduced mobility**
- **Added Ethernet and upgraded CPU card**
  - **Speeds up development cycle**
  - **Speeds up on board video processing to 10hz**

Sandia National Laboratories

November Demonstration

- **Demonstrated:**
  - **Automatic Placement of MID sensors**
  - **Non-VMD Robots relay MIDS signal**
  - **Video Tracking of Targets**
    - **MIDS trigger attracts Focus of assigned VMD Robots**
    - **Multiple target tracking**
    - **Robots report Bearing to Target**

Sandia National Laboratories

Tasks Since Demonstration

- Completed Upgrade to Windows 2000
  - Builder1 transition to Builder 5
  - Joystick reworked
- Characterization
  - Accuracy of Bearing to Target Measurement
  - Compass calibration
  - Tilt compensation
- Video Tape of Current Capability

Sandia National Laboratories

Current Tasks and Issues

- Accuracy of Bearing to Target Measurement
- Multi-Target Tracking Integration into vehicle code
- Triangulation in 3D
  - Prediction and smoothing
  - Least Squares or Median of Pairs
- 3D Terrain Display
- Vehicle Upgrade –vs- Progress

Sandia National Laboratories

Conclusions

- **Demonstrated Robotic Vehicle Deployable Video Tracking System Integrated with Miniature Intrusion Detection Sensors.**
- **Necessary Refinements Ongoing**
- **Identified Promising Areas of Future Work**
  - **Integrate Vehicles as Sensoria Nodes**
  - **Self Healing Sensor Network**
  - **Remote, Optimal Sensor Placement**
  - **Mobile response to predicted target location**

Sandia National Laboratories